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A Unique Salt Industry in Chile

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A UNIQUE SALT INDUSTRY IN CHILE[1]

ONE of the most unique methods of mining common salt is that employed at Lagunas, in the Province of Tarapaca, Chile. Salt deposits in form available for commercial extraction occur at many places and in large quantities all over the world. It is, indeed, fortunate that an article which is such a daily necessity should occur so generally in a way that the production of it is simple and inexpensive, yet probably nowhere is salt produced in quite so simple a way as at Lagunas. Here nature does everything except sack the salt and place it in the cars for shipment.

[1] By Joseph T. Singewald, jr., and Benjamin Le Roy Miller.

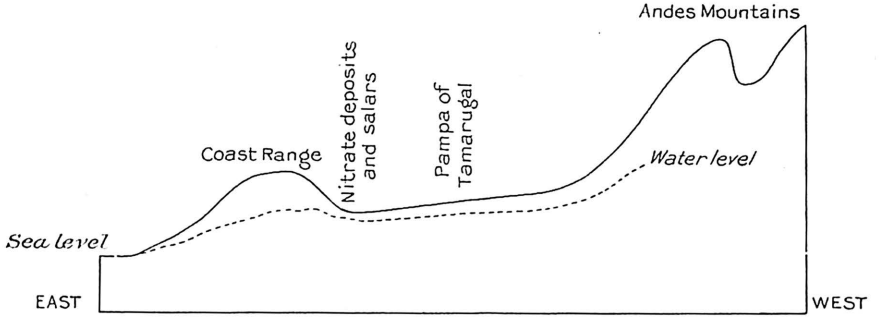


FIG. 1.—CROSS SECTION OF TAMARUGAL PAMPA, CHILE.

The Lagunas salt works are located in one of the "salars" that are so abundant in the Tamarugal pampa, as the great flat desert in which the nitrate deposits occur is called. In the above figure, which shows and east-west cross section, the vertical scale has been exaggerated in order to more clearly bring out certain relations discussed in the article.

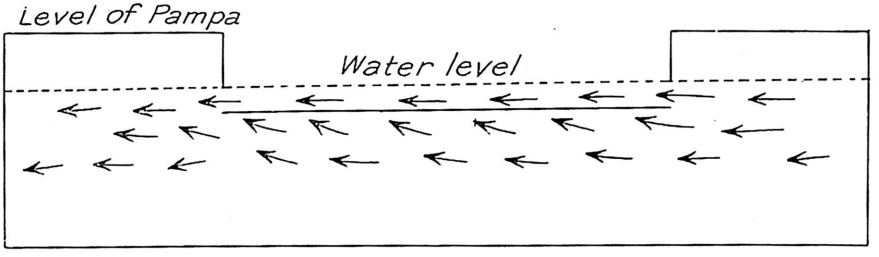


FIG. 2.—ILLUSTRATING MOVEMENT OF GROUND WATER NEAR SALT DITCH.

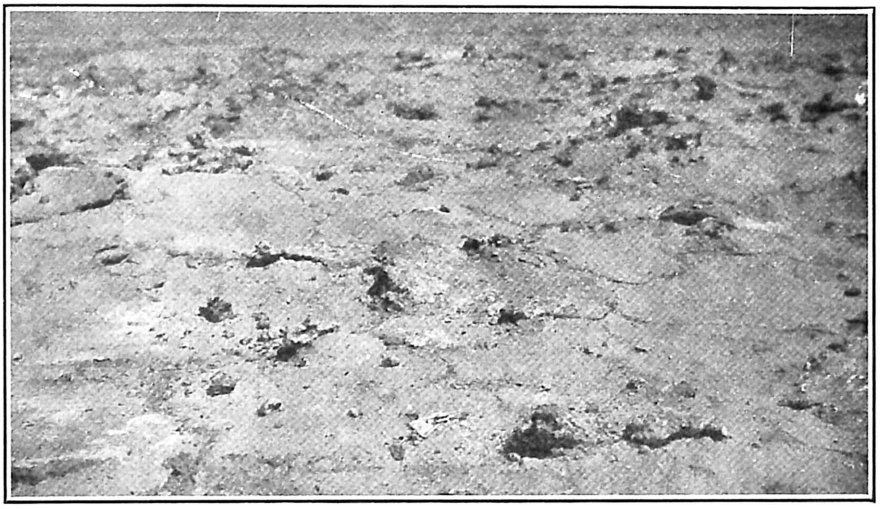
The diagram shows in a general way the movement of the ground water in the immediate vicinity of a salt ditch, there being a general lateral movement and an upward component to replace the water lost by evaporation, as fully explained in the text.

Lagunas lies at the south end of the Iquique nitrate field, which is the most important of the nitrate districts that have made Chile world famous and for 30 years have furnished the bulk of the revenues of the Chilean Government. It is connected with the sea by means of the south branch of the Nitrate Railways through the port of Iquique, that lies 89 miles to the north. The same causes and conditions that have made possible the accumulation of and preservation of the wonderful nitrate deposits have enabled the establishment of this unusual salt industry.

The Lagunas salt works are located in one of the "salars" that are so abundant in the Tamarugal pampa, as the great flat desert in which the nitrate deposits occur is called. The Tamarugal pampa is bounded on the east by the western range of the Andes and on the west by the Coast Range of mountains. These topographic features are shown in the east-west cross section in figure 1, in which the vertical scale has been exaggerated in order to more clearly bring out certain relations that will be discussed farther on. The pampa is a country characterized by an almost complete absence of rainfall. Winds that blow across the continent of South America from the east are laden with moisture. As they reach the eastern side of the Andes they are deflected upward. This movement causes a rapid cooling of the air, due to the lower temperatures prevailing at higher altitudes and to the decrease in atmospheric pressure. Consequently, these moisture-laden air currents precipitate their moisture most copiously on the eastern Andean slopes and reach the western side of the mountains practically devoid of moisture. Instead of causing rainfall in the pampa country, these winds evaporate with extreme avidity whatever moisture they may come in contact with.

Almost equally dry are the winds that blow across the pampa from the Pacific Ocean. A short distance off the west coast of South America is a cold northerly current, known as the Humboldt current, that acts as unfavorably upon the climate of that coast as does the Gulf Stream favorably upon the climate of the Atlantic coast of the United States. The prevailing winds along this west coast are the westerly winds coming in from the sea. As they cross the zone of cold water of the Humboldt current, they are chilled and lose most of their water content. Then on reaching the coast and being warmed up again they are deficient in moisture and also have a great evaporating capacity.

Hence, whether it is the prevailing westerly winds or the occasional winds that sweep across the pampa from the Andes on the east that are blowing, the air over the pampa is nearly always extremely dry and evaporates water rather than precipitates it. These atmospheric conditions have made the pampa a desert in the strictest sense of the word. We speak of deserts in the Great Basin region of the



SURFACE OF A TYPICAL "SALAR."

The "salars" are easily recognizable by the character of the surface. The force of crystallization of the salt under the surface has produced little hummocks, and this tension has caused the surface to crack.

Photo by I. F. Scheeler.

ON A VERITABLE SALT "LAKE."

The same causes and conditions that have made possible the accumulation and preservation of the wonderful nitrate deposits of Chile have operated to produce these large areas of sodium chloride, or common salt.

western United States, but there one does see an occasional clump of sagebrush, or patch of greasewood, or at least a few scattered cacti, whereas one can search in vain for the smallest evidence of living vegetation over square miles of the pampa.

Now let us consider how these extreme conditions of parched winds cloudless sky, and hot tropical sun have made possible the simple method of extracting salt in use here. As indicated in figure 1, the pampa is a flat plain with a gentle westward slope away from the Andes toward the coast hills. The site of the present pampa was once a large broad valley that has been filled up with gravel, sand, and silt washed down in large measure from the summits and slopes of the Andes Mountains that tower above it on the east side. In past ages rainfall was more abundant in these regions than now, and the water collected in numerous depressions in the surface of the pampa in the form of inland lakes. On account of the westward slope of the pampa the lakes formed mostly along its western edge. The waters draining into the lakes carried with them the soluble salts leached out of and formed by the disintegration of the rocks of the surrounding country, and since they had no outlet they became more and more saline, just as in the case of our own Great Salt Lake and the Dead Sea. As aridity increased the lakes finally dried up, giving rise to the highly saline depressions in the pampa that are known in Spanish as "salars." The "salars" are characterized by an abundance of sodium chloride, or common salt, in the underlying soil and the absence of nitrate. The nitrate occurs in the surrounding higher lying ground. One must not be misled into thinking of these "salars" as occupying deep depressions, for in general they are so gentle as to be scarcely perceptible to the eye. They are at once recognizable, however, by the character of the surface. The force of crystallization of the salt under the surface has produced little hummocks and this tension has caused the surface to crack, so that the "salars" are characterized by a broken hummocky surface, whereas that of the pampa round about is smooth and even. While there are enormous quantities of salt underlying these "salars," it is usually so mingled with the detrital rock material of the pampa as to be unusable in its natural state.

The only waters circulating at the present time across the pampa are the underground waters which have a general direction of flow from the higher slopes of the Andes, their feeding ground, westward under the pampa to the sea. The upper surface of ground-water level has approximately the shape of the surface of the earth above it, but with less accentuated relief. In other words, it is nearer the surface at the points of lowest elevation and farther from the surface under the highest points. These relations are illustrated in figure 1

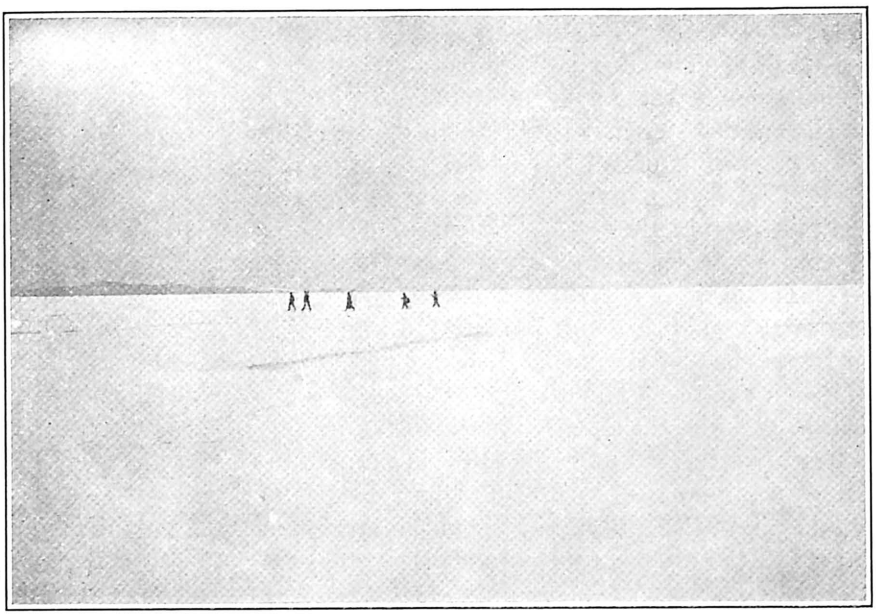
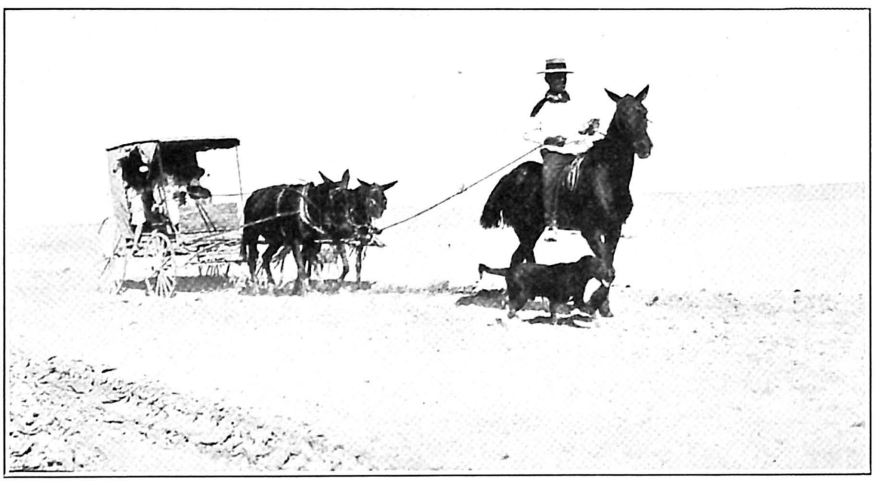


Photo by I. F. Scheeler.

WALKING OVER A FIELD OF GENUINE SALT.

A remarkable deposit of salt, similar to this, is located at Lahunas, in the Province of Tarapaca, Chile. "Here nature does everything except sack the salt and place it in the cars for shipment."



ON THE NITRATE PAMPA OF TAMARUGAL, CHILE.

One section of the world where it has never rained and probably never will, the result being an absolutely arid desert. A clear explanation of this phenomenon may be found in the text of Messrs. Singewald and Miller's article, "A Unique Salt Industry in Chile."

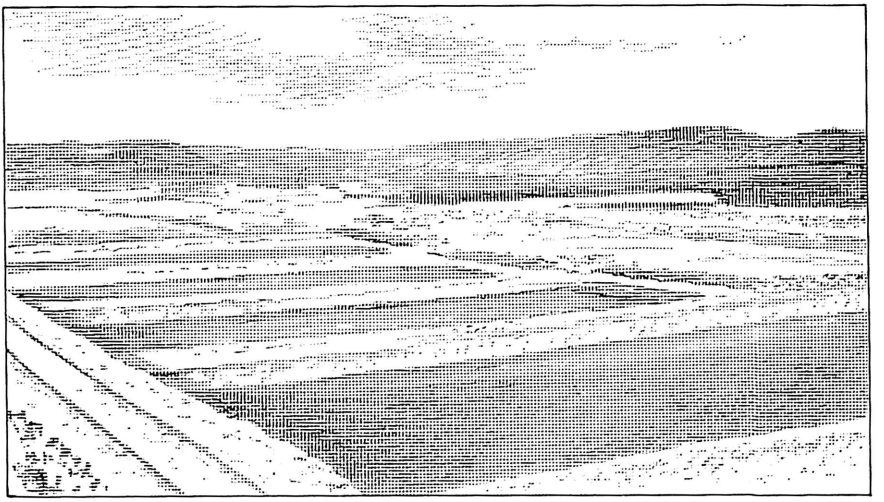
Consequently, the underground waters are nearest the surface underneath the "salars" on the west side of the pampa.

One of the striking features of the pampa is the shallow depth at which ground water is encountered. In even less arid regions than this ground water usually lies at a depth of hundreds, and in some cases thousands of feet, whereas, in the nitrate fields, the depth of ground water is measured in tens of feet. Still more remarkable is the fact that in the "salar" in question, where the salt is produced, ground water lies at a depth of only 3 to 3½ feet.

The conditions described above have very ingeniously been made use of to establish a salt industry in this "salar." Ditches are cut in the surface of the "salar" to a depth of 8 inches below the level of ground water. The ditches, exposed to the hot, dry sunshine and parched winds, act as very efficient evaporating pans, and the saline water underlying the "salar" that is exposed in the ditches is evaporated to the point of saturation when salt begins to crystallize out in the bottom of the ditches. Since the level of ground water is maintained in the ditches by the constant seeping in of the ground water, the salt continues to accumulate until it reaches the height of ground water, or a thickness of 8 inches, when the ditch has dried up. The salt is then shoveled out by hand, and as it is removed the water again comes in. The men who do this stand in the concentrated brine solution in their bare feet, with the result that their feet become dreadfully sore and they frequently are compelled to lay off until they heal again. After a ditch has its salt removed, the same process is gone through again, and can be repeated indefinitely. The rate at which the salt forms is 1 inch in 15 days, or at the rate of three crops of salt a year.

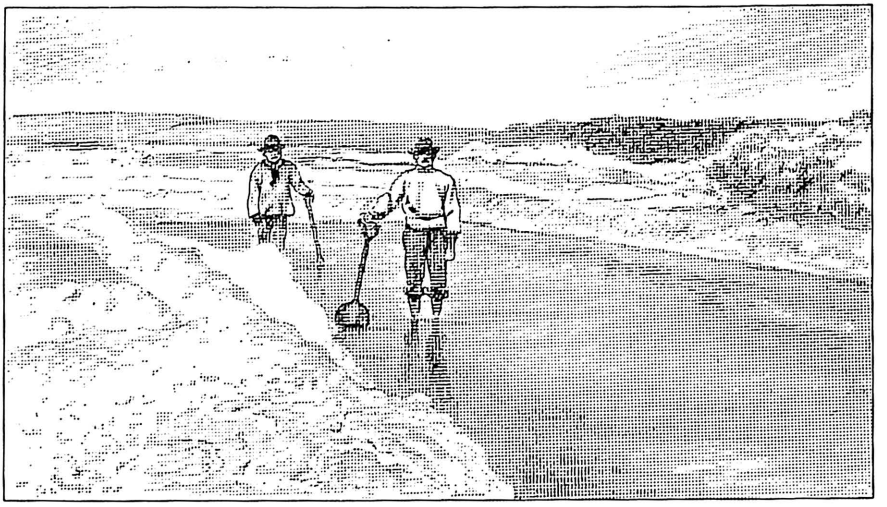
The salt is shoveled out on the ground between the ditches and there allowed to drain and dry, and is then packed in sacks holding 2 quintals each, or about 200 pounds. Most of it is of a beautifully snowy white color and quite pure enough for table use. Occasionally, however, the violent wind storms which sweep across the pampa blow enough of the yellow pampa dust into the ditches to give the salt a dirty color. Such salt is kept separate from the rest and sold for cheaper uses. A branch of the Nitrate Railways to the South Lagunas Nitrate Oficina runs between the salt ditches and affords very convenient loading and shipping facilities.

This salt industry was established on a very small scale about 10 years ago and has proved to be such an inexpensive method of producing salt that it has grown rapidly, until now there are 150 of these evaporating ditches. Each ditch covers an area ranging from about 40 by 40 feet to 40 by 100 feet. The output is now about 16,000 quintals a month, which is roughly equivalent to about 10,000 tons annually.



VIEW OF SALT DITCHES AT LAGUNAS, CHILE.

"Ditches are cut in the surface of the 'salar' to a depth of 8 inches below the level of ground water. The ditches, exposed to the hot, dry sunshine and parched winds, act as very efficient evaporating pans, and the saline water underlying the 'salar' that is exposed in the ditches is evaporated to the point of saturation, when salt begins to crystallize out in the bottom of the ditches."



SHOVELING THE SALT FROM THE DITCHES.

"The salt is shoveled out on the ground between the ditches and there allowed to drain and dry, and is then packed in sacks holding 2 quintals, or about 200 pounds, each.

It is a rather curious fact that it has been found if the ditches are cut to more than 8 inches below ground-water level, salt will not crystallize. The explanation of this is simple. The very slow movement of the underground circulation is constantly causing some of the concentrated water to flow out of the ditches and more dilute water to flow in. Figure 2 shows, in a general way, the movement of the ground water in the immediate vicinity of a ditch. There is a general lateral movement and an upward component to replace the water lost by evaporation. Moreover, diffusion is always tending to equalize the concentration of the waters in the ditch and that of the surrounding ground water. These two processes are at work undoing what the solar evaporation is doing. Consequently evaporation must proceed at a rate sufficiently rapid to more than offset the dissipating influences of flow of ground water and diffusion. The amount of evaporation depends on the amount of surface exposed to evaporation and on the temperature of the evaporating liquid. The first factor is the same irrespective of the depth of the solution. The depth has an influence on the amount of evaporation in that the shallower the water the warmer it will get, and hence the greater the evaporation. But depth has a still greater effect on the rate of evaporation. If a given amount of water is evaporated per unit area of surface exposed, the rate of evaporation is only one-half as great in the case of a body of water 16 inches deep that it is in the case of a body only 8 inches deep. From these considerations it is clear that the rate of evaporation decreases more rapidly with increasing depth of solution than at a rate inversely proportional to the depth of the evaporating body of water. And this is the explanation of the failure of salt to form when the ditches are cut deeper than 8 inches—the rate of evaporation is cut down to such an extent that flow and diffusion are able to prevent the point of saturation being reached.

Another interesting point to note is that only within certain parts of the "salar" will salt form. Ditches cut outside of these areas remain full of water that never deposits salt. From this fact it would appear that the normal ground water is not sufficiently salt to concentrate rapidly enough to reach the point of saturation, and that the areas where the salt forms are underlain by beds of salt that raise the salt content of the water in their immediate vicinity.